

Title: **“Improved Miscible Nitrogen Flood Performance Utilizing
Advanced Reservoir Characterization and Horizontal Laterals
in a Class I Reservoir – East Binger (Marchand) Unit”**

Type of Report: **Quarterly Technical Progress (Report No. 15121R06)**

Reporting Period Start: **July 1, 2001**

Reporting Period End: **September 30, 2001**

Principal Author/Investigator: **Joe Sinner**

Report Date: **October 26, 2001**

Cooperative Agreement No: **DE-FC26-00BC15121**

Contractor Name & Address: **Binger Operations, LLC
P. O. Box 2850
Cody, Wyoming 82414**

DOE Project Manager: **Gary Walker, National Petroleum Technology Office**

Disclaimer

“This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.”

Abstract

Progress on the East Binger Unit (EBU) project has slowed as difficulties have been encountered with obtaining satisfactory production from well EBU 37G-3H, the new horizontal well. Remedial operations have been conducted and stimulation operations were about to get under way at the end of the reporting period.

International Reservoir Technologies, Inc. has made additional progress on the pilot area simulation model, reaching a point with the history match that we are awaiting more definitive production data from the horizontal well.

Planning future development of the EBU hinges on evaluating the results of well EBU 37G-3H. Performance of this well must be understood in order to evaluate development scenarios involving horizontal wells and compare them with development scenarios involving vertical wells.

TABLE OF CONTENTS

<u>INTRODUCTION</u>	<u>1</u>
<u>EXECUTIVE SUMMARY</u>	<u>1</u>
<u>RESULTS AND DISCUSSION</u>	<u>1</u>
TASK 1.1.2 – RESERVOIR DATA COLLECTION	1
TASK 1.1.5 – BUILD PILOT AREA MODEL	2
<u>CONCLUSION</u>	<u>3</u>

LIST OF GRAPHICAL MATERIALS

FIGURE 1. DATA AND INTERPRETED RESULTS OF A PRESSURE BUILD-UP TEST CONDUCTED ON EBU 37G-3H.....	4
FIGURE 2. CROSS-SECTION SHOWING THE LOCATION OF HORIZONTAL WELL EBU 37G-3H WITHIN THE PILOT MODEL.....	5
FIGURE 3. CELL BY CELL RATE AND PRESSURE PREDICTIONS FOR EBU 37G-3H..	6

Quarterly Technical Progress Report – 3rd Quarter 2001

Introduction

Planning future development of the East Binger (Marchand) Unit hinges on evaluating the results of well EBU 37G-3H, the first horizontal well drilled in the unit. Performance of this well must be understood in order to evaluate development scenarios involving horizontal wells and compare them with development scenarios involving vertical wells.

EBU 37G-3H was drilled in the second quarter of 2001. Many difficulties were encountered during the drilling, as discussed in a previous report. Most importantly, these difficulties led to a change in the planned method of drilling the horizontal portion of the hole, from underbalanced with a nitrogen-foamed drilling fluid to overbalanced with a weighted oil base mud. This appears to have caused significant damage to the formation and additional difficulties in obtaining satisfactory production from the horizontal well.

Executive Summary

Progress on the East Binger Unit project has slowed as difficulties have been encountered with obtaining satisfactory production from well EBU 37-3H, the new horizontal well. Remedial operations have been conducted and stimulation operations were about to get under way at the end of the reporting period.

International Reservoir Technologies, Inc. has made additional progress on the pilot area simulation model, reaching a point with the history match that they are awaiting more definitive production data from the horizontal well.

Results and Discussion

The following is a detailed review of the work conducted in this reporting period.

Task 1.1.2 – Reservoir Data Collection

Calibration of Horizontal Productivity

One of the major items planned within this task is the calibration of horizontal performance in the reservoir simulation model to actual field performance. Horizontal well EBU 37G-3H was drilled during the second quarter of 2001. Most of the work in the third quarter has focused on the completion of this well.

Drilling operations on EBU 37G-3H were completed in mid-July, with a liner run through the curved portion of the well. The liner was cemented in place using an external casing packer (ECP) at the liner shoe, with approximately 1300' of 6-1/8" horizontal open hole left exposed. After disappointing flow results, it was determined that the ECP had failed, allowing cement to escape about 250' past the liner shoe into the open hole. This was drilled out and the horizontal section was washed with gelled diesel, recovering significant amounts of cement, mud, and mud solids. The well subsequently flowed 5-10 bopd and 400 mcf/d. A gas sample was analyzed and found to contain 78% nitrogen.

Interpretation of a pressure build-up run in early September indicates the well is damaged. Figure 1 shows the data and interpreted results of this test – average horizontal permeability to oil of 0.01 md, skin of 8.8, and average reservoir pressure of 4300 psi. After various stimulation options were investigated, a series of intervals were perforated in an attempt to get beyond any very near wellbore damage. The options investigated were as follows:

- (1) Perforate open hole with casing guns.
- (2) Perforate open hole with through-tubing guns.
- (3) Create notches in the rock with coil tubing and a special nozzle, then pump a hydraulic fracture treatment. The notches would serve as frac initiation points.
- (4) Run a liner, perforate, and frac.

Options (1) and (4) would have required under-reaming the hole to remove the remaining cement in the horizontal section, adding cost and risk. Option (3) committed to a frac without testing whether or not perforating could get beyond the damage. Option (2) was chosen to test that concept and because it is thought that the perforated intervals will also create weak points for frac initiation, similar to the notching of option (3).

Production improved only slightly following the perforating, to 10-15 bopd and 560 – 630 mcf/d. At the time of this report, plans were being finalized to frac the well.

Task 1.1.5 – Build Pilot Area Model

The history-matching phase of the pilot area model reached a point of awaiting results of the horizontal well. A couple of global changes were made to the reservoir description, as well as some local modifications around various wells. The global changes were as follows:

1. Vertical permeability was reduced by a factor of 50 [$k_v(\text{new}) = k_v(\text{old}) * 0.02$], consistent with observations made and discussed in report 15121R02.
2. Horizontal permeability was reduced by a factor of 2 [$k_h(\text{new}) = k_h(\text{old}) * 0.5$], in an attempt to better match field pressures. As discussed in report 15121R03, the average reservoir pressure in the model appears to be fairly close to the average field pressure, but

the pressure gradient between injectors and producers is much steeper in the field than predicted by the model. This change improved this gradient in some areas, but in others additional work needs to be done. This will be investigated as more results from the horizontal well are achieved.

Some additional simulation work was done in an effort to better understand field observations with the new horizontal well, EBU 37G-3H. The placement of the open hole completion was calculated and is shown in Figure 2. It can be seen in this figure that the model predicts the area containing the heel of the well (the end closer to 37G-1) to be somewhat gas-swept. As discussed in previous reports, this well was originally planned as an injection well. Due to the difficulties and cost of drilling the well, it was decided to attempt to first complete the well as a producer.

Figure 3 shows the cell-by-cell predicted production for the well. High gas-oil-ratio (GOR) production is predicted from the heel area, consistent with the higher gas saturations shown in this area in Figure 2.

Other observations can be made of the model predictions shown in Figure 3. First, the model's predicted reservoir pressure is too low – about 3800 psi versus the 4300 psi measured. Second, the model predicts much higher oil and gas rates from the well than what has been seen to date, providing further support to the interpretation that the well is significantly damaged.

Conclusion

Progress on the East Binger Unit project has been slowed by difficulties in understanding and overcoming problems with EBU 37G-3H, the new horizontal well. Interpretation of a pressure build-up test indicates the well is damaged. Stimulation operations are planned.

Work on the pilot area simulation model has reached a point with the history match that it is awaiting more definitive production data from the horizontal well. Further work on evaluating different development alternatives will follow after results of stimulation work on EBU 37G-3H have been understood and properly incorporated into the simulation model.

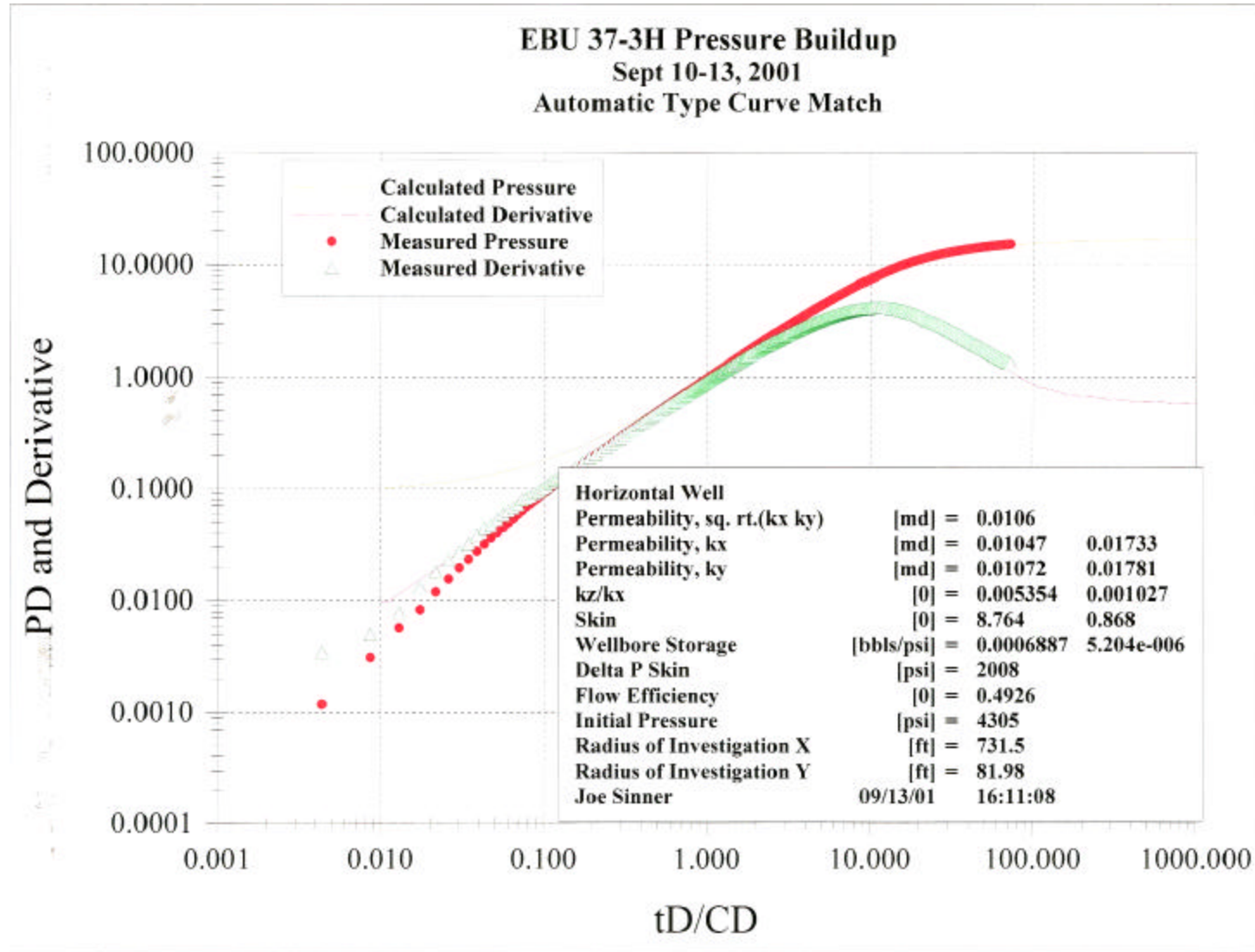


Figure 1. Data and interpreted results of a pressure build-up test conducted on EBU 37G-3H.

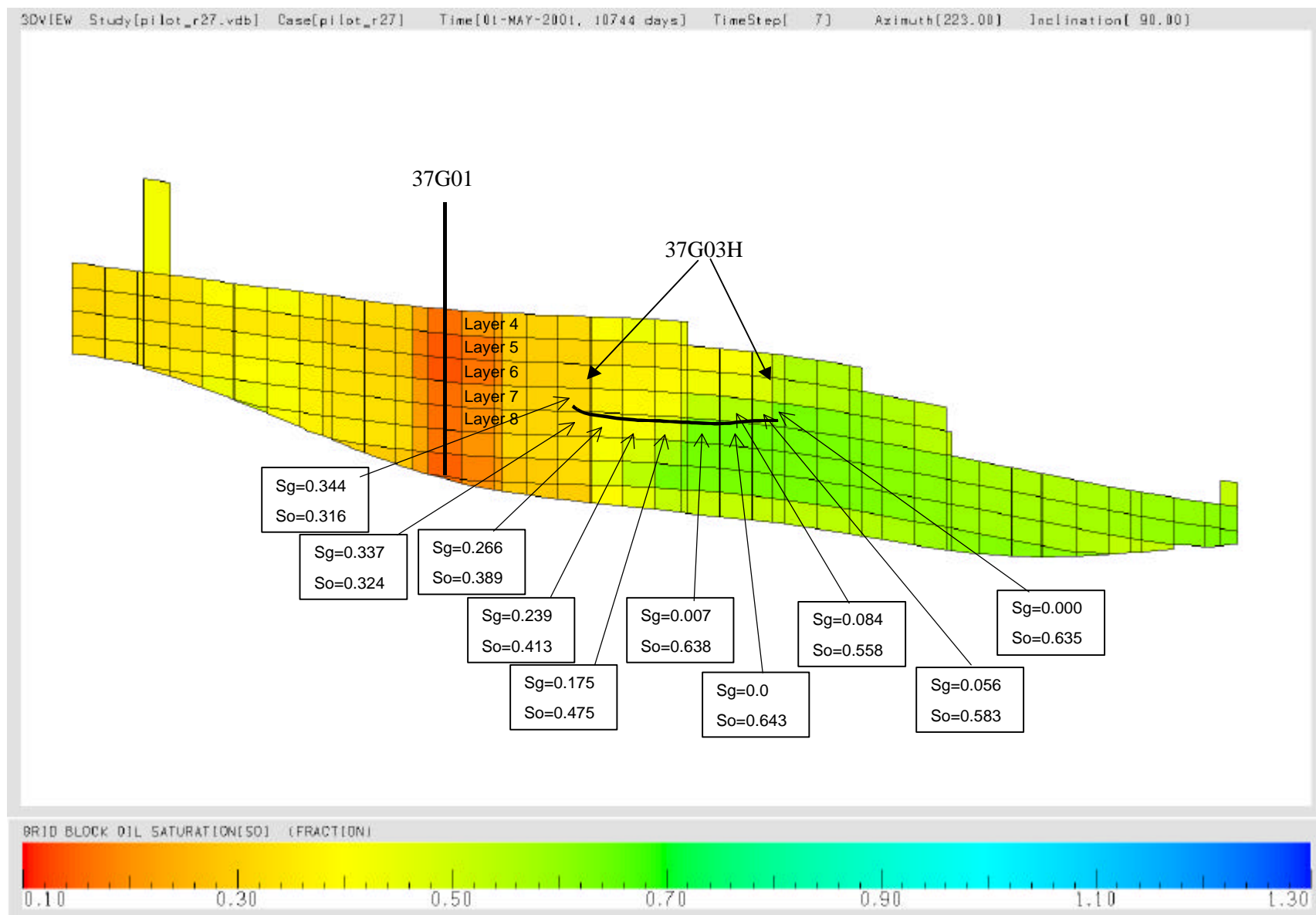


Figure 2. Cross-section showing the location of horizontal well EBU 37G-3H within the pilot model. Color indicates oil saturation within each model cell.

Pilot Model Forecast Case " <u>pm_fore2ar</u> "								DAILY PRODUCTION					PRESSURES , PSIA				
All cells along open hole section are open to production.								OIL STB/D	GAS MSCF/D	WATER STB/D	GOR SCF/ STB	WATER CUT FRAC.	GRID BLOCK	GRID BLOCK @DATUM	BOTTOM HOLE		
WELL			PERF LOCATION			UNIT	STATUS										
NO.	NAME	GC#	I	J	LAYER			UNIT	STATUS								
At 9-2-2001	108 W37G03	1	14	22	7	0	ON	1.7	236.9	0.0	140,000	0.001	3,790	3,788	759		
			14	22	8	0	ON	2.1	282.7	0.0	136,000	0.001	3,768	3,765	760		
			13	22	8	0	ON	0.6	40.0	0.0	72,139	0.001	3,861	3,858	761		
			13	23	8	0	ON	7.0	390.1	0.0	56,103	0.001	3,565	3,562	761		
			13	24	8	0	ON	7.6	307.2	0.0	40,663	0.001	3,546	3,543	761		
			13	25	8	0	ON	7.7	174.5	0.0	22,624	0	3,665	3,662	761		
			12	25	8	0	ON	1.3	5.8	0.0	4,294	0	3,913	3,909	761		
			12	26	8	0	ON	31.4	33.9	0.0	1,081	0	3,813	3,809	761		
			12	27	8	0	ON	18.2	16.1	0.0	885	0	3,789	3,786	760		
			12	27	7	0	ON	9.4	50.4	0.0	5,340	0	3,844	3,842	760		
			12	28	7	0	ON	4.6	12.3	0.0	2,683	0	3,919	3,918	759		
			11	28	7	0	ON	2.9	2.9	0.0	992	0	3,872	3,870	759		
											94.4	1,552.5	0.0	16,447	0	758	

Figure 3. Cell by cell rate and pressure predictions for EBU 37G-3H. The cells are listed in order from the heel to the toe of the open hole section. Cell I=14, J=22, Layer = 7 is at the heel. Cell I=11, J=28, Layer =7 is at the toe.